

Use of Relational Database Management System by Clinicians to Create Automated MICU Progress Note from Existent Data Sources

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We designed and built an application called MD Assist™ that compiles data from several hospital databases to create reports used for daily house officer rounding in the medical intensive care unit (MICU). After rounding, the report becomes the objective portion of the daily "SOAP" MICU progress note. All data used in the automated note was available in digital format residing in an institution wide Sybase data repository which had been built to fulfill data needs of the parent enterprise. From initial design of target output through actual creation and implementation in the MICU, MD Assist™ was created by physicians with only consultative help from information systems (IS). This project demonstrated a method for rapidly developing time saving, clinically useful applications using a comprehensive clinical data repository.

INTRODUCTION

Digital monitoring devices and computer systems are used extensively in the MICU. Dedicated ICU bedside data collection systems, when present, are most useful for collecting physiologic and laboratory data and building flow sheets designed for nursing documentation. They are often not as successful in creating concise, clinically useful reports that aid physicians in streamlining the work process or making decisions, two key factors reported to be necessary for physician acceptance of medical software (1,2). Several groups have designed critical care applications which have been enthusiastically accepted by critical care practitioners (3-5).

Clinicians in most critical care settings spend considerable time manually unifying information from lab systems, nursing flow sheets, medication records, and radiology reports to build a template for morning rounds and ultimately the daily progress note. Because almost all of the information that clinicians routinely sought existed in digital form at Beth Israel Deaconess Medical Center, the medical house staff, encouraged by members of the

Pulmonary and Critical Care Division, decided to attempt building an application using commercial tools familiar to them (Microsoft Access/Visual Basic) to assemble these data into an electronic report that could replace the manually created "rounding sheet" and then be incorporated into the daily progress note.

SYSTEM ENVIRONMENT

The Beth Israel Deaconess Medical Center which has resulted from the merger of the Beth Israel Hospital and the New England Deaconess Hospital is a 673 bed academic tertiary care institution with an average of 40,158 discharges a year. MD Assist™ was developed on the West campus (NEDH) to service ICUs which have a combined capacity of 24 beds. The MICU has an average daily census of 6-8 patients. All of these ICUs are equipped with Hewlett Packard CareVue® workstations. Some patient data is manually input into CareVue® by nursing and respiratory staff but most data enters CareVue® from a variety of bedside monitoring devices (after verification by nursing) using smart interfaces. The CareVue® system has been interfaced with the hospital network. Due to current technical constraints between CareVue® and the hospital's networked data systems, only live laboratory data (excluding microbiology results) and demographic data is transferred into CareVue®. Information from other systems such as radiology, microbiology and pharmacy are obtained outside of the CareVue® environment and are not available to CareVue® for report generation.

The hospital information system, like the medical center, is currently in a state of transition. The older system on the West Campus, an IBM mainframe is being disassembled. A replacement system is currently being investigated while a transition system developed using Power Builder/Sybase under MS Windows 3.1 is providing data viewing capabilities. Both systems interface with several ancillary databases including Community Health Computing Microbiology and

Laboratory Systems, a Cerner MSMedS Pharmacy system, and a home grown radiology system. [See Figure 1] The transition system was developed to utilize the hospital's Structured Query Language (SQL) compliant database termed the Clinical Data Repository (CDR). The CDR is a Sybase relational database containing clinical data back to 1984 in some tables. The CDR is primarily comprised of inpatient data including discharges summaries completed using the hospital's On-line discharge summary facility (6). Tables in the CDR are designed to allow relatively intuitive access to complex data by joining multiple tables.

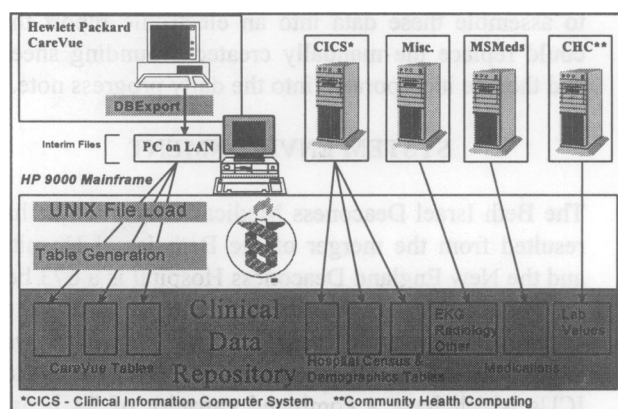


Figure 1- Overview of Beth Israel Deaconess Medical Center- West Campus network structure.

METHODS

A committee of resident physicians with recent MICU experience was assembled to determine what data was needed to build an optimal rounding report. They regarded the goal of the project as helping their peers to improve the care they provided to MICU patients by assuring that the most comprehensive information set possible was assembled for review. Some of their requests, particularly for graphical trends, could not be accomplished without automation. Relieved of the burden of collecting and recording data, house officers could then spend maximal time in cognitive and direct service activities.

An initial effort at generating the prototype note from within the CareVue® environment was unsuccessful because insufficient data for a comprehensive report was represented in the CareVue® database. The working group then decided to use the CDR as the infrastructure for the automated report. The structure of the West Campus CDR is outlined in Figure (1). The CDR contained

the majority of information necessary to create the proposed note, including real-time pharmacy and lab data. It was technically easier to incorporate data from CareVue® into tables in the CDR using CareVue® DBExport then vice-versa. We therefore chose to build the report off of this richer, easier to populate, data source.

For the initial iteration of *MD Assist™*, DBExport was configured to export data once a day for the preceding 24hrs of selected data points. The task start time was set at 7am to capture 6am - 6am data. This time was chosen to match the configured 6am 24 hour I/O summation time in CareVue® and allow report generation prior to the start of MICU rounds. The data points exported to the CDR were those chosen by the initial committee with additional points included for ongoing infectious disease and epidemiology studies. Once DBExport created the intermediate files on a networked PC, a network process appended the data to the corresponding tables in the CDR. The timing and configuration of field transfer by DBExport was accomplished with consultation from clinical engineering and IS.

MD Assist™ was created on a networked Pentium®-based PC using a standard relational database management system (RDMS) software package, Microsoft Access 2.0. The PC's ODBC driver was configured with the help of IS so that Access could send SQL commands to the CDR server to retrieve required information. Initial development took place at an isolated PC in the Critical Care Department. Throughout the development period there were numerous feedback sessions with house staff and attending physicians to guide development.

To assure data accuracy, the printed reports were manually compared back to original data sources on a daily basis during a month long pre-pilot phase. When known bugs had been removed or documented, IS reviewed the program structure to ensure the basic soundness of the underlying queries. A user-friendly interface was created under MS Access and Access Basic that allowed easy launching and running of the automated report.

Password protection was put in place to prevent report generation by unauthorized individuals. Permissions were assigned to user accounts to prevent modification of the underlying queries and visualization of potentially sensitive data from the CDR. Once data security issues had been addressed and the soundness of underlying SQL queries verified, *MD Assist™* was

installed on a networked PC in the MICU and used to generate daily automated progress notes.

*MD Assist*TM was first made available in the MICU in November of 1996. During the initial month, the note was used in parallel with the established manual rounding method. This use of redundant information sources served to both familiarize teams with *MD Assist*TM format as well as to monitor the new system for errors. Systematic error reporting was facilitated through three major mechanisms: error reporting sheets available in the ICUs, verbal reporting through frequent feedback sessions and a staff member available by pager and E-Mail.

RESULTS

Since the initial installation in the MICU in November, 612 automated reports [Figure (2)] have been generated during a total of 145 MICU admissions. An average of 210 data points were included per report depending on patient acuity of illness. The clinical data from CareVue® comprised the majority of data points. DBExport transferred 4-10MB of data during daily uploads to the CDR depending on the MICU census as well as the number of data intensive monitors and devices in place. This resulted in a total load time of 40-50 minutes from DBExport execution to CareVue® data availability on the CDR. Further variance in this time was created by overall network load during CareVue® data processing. The daily vital sign graph on the report includes an average of 69 data points (excluding time tags) from CareVue® which are represented in visual format.

The majority of the programming errors which were encountered during the development of *MD Assist*TM were removed during careful testing during the pre-pilot month. These consisted mostly of data formatting errors caused by newly encountered data sets and by variance of incoming data from the other networks. At the time of actual installation in the ICU, new formatting errors occurred very infrequently.

*MD Assist*TM proved robust in data delivery. Complete data sets combining data from CareVue® and the CDR were delivered for 121 out of 127 days (95.3%) since program installation. This includes 11 days where reports were generated after the start of rounds but were still used for the basis the daily progress note.

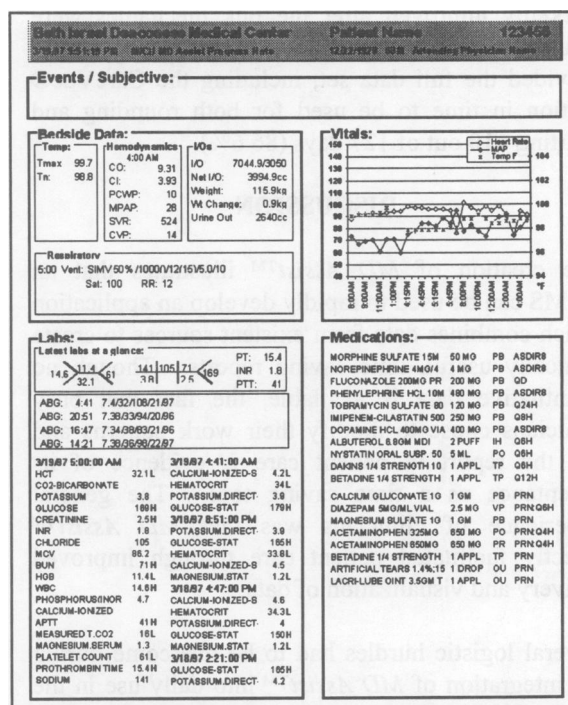


Figure 2 - Sample of *MD Assist*TM Rounding Report

While overall program reliability proved high, data omissions and failure of the CareVue® to CDR link were initially problematic. These failures created reports with Intact Demographic, Laboratory and Medication data but the CareVue® data sections remained blank. Five such instances have occurred since installation, necessitating manual collection of CareVue® data. Table (1) provides a breakdown of the causes of incomplete note generation.

Table 1 - Errors causing *MD Assist*TM Failure

Etiology	Instances
Failure of <i>MD Assist</i> TM secondary to corrupted internal table	1
CareVue® Software upgrade requiring system to go off-line	1
Failure of DBExport to execute	1
Aberrant data from CareVue® causing failure of CDR CareVue® table generation process	3
CareVue® to CDR data transfer completed after start of rounds	Initial* 10 Current* 1

*CareVue® to CDR link was adjusted 2/27/97

The first iteration of the CareVue® to CDR link, while generally reliable, caused occasional problems in generating the CDR CareVue® tables early enough for the report to be generated in time for rounds. This

markedly improved after the link mechanics were adjusted with the help of IS. Overall, *MD Assist*TM provided the full data set, including the CareVue® portion in time to be used for both rounding and charting 110 out of 127 days (86.6%).

DISCUSSION

The creation of *MD Assist*TM illustrates that an RDMS can be used to rapidly develop an application which combines data from existent sources to create clinically useful, time saving reports. Though no quantitative data is available, the fact that busy clinicians chose to modify their work patterns and use the report in patient care is evidence of its acceptance as a time saving tool. The general experience of clinicians was that *MD Assist*TM directly facilitated patient care through improved delivery and visualization of data.

Several logistic hurdles had to be overcome during the integration of *MD Assist*TM into daily use in the MICU. The failures of *MD Assist*TM or the CareVue® to CDR link were relatively rare. Improved error trapping in *MD Assist*TM, DBExport and network processes involved in creating the CDR CareVue® tables should markedly reduce failures in the future. Improving data entry and verification methods from within CareVue® will also further enhance reliability.

Adjusting the timing of data transfer was a more problematic issue. Prior to building this application, the CareVue® data transfer to the CDR was an archival function. After installation in the MICU it became necessary to move data in a reliable and timely manner on a daily basis. House officers expressed concern that the reports were not completed early enough to use while preparing for rounds and to allow for backup manual data gathering if the system failed. Attending physicians were concerned about having the most complete and current information for their morning rounds with the house staff. Though the report was generated reliably (with the exceptions as noted above), the initial iteration did not allow enough time for variance caused by such factors as a large census, unusually large data loads and increased network traffic. Therefore, the report was sometimes not generated early enough to be reliably available for effective review prior to formal rounds with the Critical Care Attending Physician. To address this issue, DBExport was launched 30 minutes earlier, the order of table export modified and the timing of

the network processes that create the CareVue® tables on the CDR tightened. These adjustments achieved a workable balance between obtaining the most recent data possible and obtaining the report early enough to be clinically useful. If the update time were moved earlier yet, the 6 AM data points would be missed and the I/O totals in CareVue® would be out of synchrony with *MD Assist*TM reports. This could be resolved by reconfiguring CareVue® to total I/O's 5am-5am. However, this would have necessitated time commitments from both IS and nursing.

MICU team acceptance of *MD Assist*TM posed other problems. The impression that this was designed by peers, not hospital IS professionals resulted in some skepticism about the durability and reliability of the application. While the reports were used in parallel with standard written notes, MICU teams developed an appreciation for the improved legibility, standardized format of data display and increased data accuracy provided by a digital progress note.

Additionally, benefits of new elements that assisted clinical decision making, such as graphing of the previous 24hours of vital signs, enhanced physician acceptance. As the team's experience with *MD Assist*TM increased the clinicians became comfortable with the reliability and timely availability of *MD Assist*TM reports. Use of the automated reports as the primary source for objective patient information during rounds increased over the period we monitored, and the report now consistently serves as the basis of the daily progress note. House officers appreciated being relieved of the time consuming task of data gathering and found they could spend more time reviewing the morning's results and in providing direct patient service.

Beside recreating the data usually gathered manually by house officers, *MD Assist*TM offers additional aids to data analysis. While graphical displays of physiologic / laboratory trends are generally considered useful, they are rarely available in a paper based charting environment because graphs are time consuming to produce. The 24hrs vital signs graphic has become important for patient care decision making and is very popular among users.

A further advantage to clinician created ICU software using RDMS technology is that such applications tend to be modular and easily adaptable by nature. Basic modification of the report output can be accomplished without delving into SQL or Access Basic. Therefore, design modification can be done by clinicians with

only modest computing background. This enabled rapid evolution of *MD Assist*TM and its interface based on clinical team feedback. Such responsiveness encouraged active participation by critical care clinicians since they saw changes based on their input implemented in a timely manner.

Use of a RDMS allows easy migration of the core queries and software as newer and more powerful version of both RDMS software and operating systems become available. Since the application runs on Intel and MS Windows based systems, a viable migration path is virtually guaranteed to hospitals which have committed to PC information system solutions.

Very few charting applications are designed to support critical care physician activities and facilitate critical care decision making. Only a few examples can be found in the current literature (3,4,7). Unlike the HELP System at LDS Hospital in Utah (4,5), *MD Assist*TM is not an alerting system because most data is acquired by batch downloads and is therefore not "real time." While not technically a decision support system, the style of the data presentation, the graphics, the completeness and legibility of the data assist clinicians in making more informed decisions about MICU patients. *MD Assist*TM is clinician created, using affordable, readily available off-the-shelf software to access existing hospital information databases. No additional hardware was required for this project. Furthermore, such development is easily integrated into existing PC networks through local installation of run-time versions.

Use of a RDMS to generate an automated MICU progress note has been highly successful at our institution. Several key pieces of infrastructure assisted in the creation of *MD Assist*TM. The backbone of the West Campus computing system is the CDR. The active links to pharmacy and lab systems made it an ideal near one-stop data clearinghouse for this project. Additionally, though the design and creation of *MD Assist*TM was completed by clinicians, Information Services was instrumental in setting up ODBC drivers and configuring both the timing and necessary data point transfer by DBExport to the CDR. Further collaboration with IS will be necessary to bring pending microbiology results on-line. Thus, though similar projects can be initiated and developed by

clinicians in any organization, a supportive IS department with open systems expertise is essential to the success of such projects.

CONCLUSION

We have demonstrated a method of rapidly developing a time saving and clinically useful MICU rounding and charting application using readily available off-the-shelf software to access existent hospital data sources.

References

1. Tang PC, Patel VL. Major Issues In User Interface Design For Health Professional Workstations: Summary And Recommendations. *International Journal Of Bio-Medical Computing*, 34, 1994, pp. 139-148.
2. Tang PC, Annevelink J, Suermondt HJ, Young CY. Semantic Integration Of Information In A Physician's Workstation. *International Journal Of Bio-Medical Computing*, 35, 1994, pp. 47-60.
3. Michael PA. Physician-Directed Software Design: The Role Of Utilization Statistics And User Input In Enhancing HELP Results Review Capabilities. *Proceedings, The Seventeenth Annual Symposium On Computer Applications In Medical Care* 1993, pp. 107-111.
4. Huff SM, Haug PJ, Stevens LE, Dupont RC, Pryor TA. HELP The Next generation: A New Client-Server Architecture. *Proceedings, The Seventeenth Annual Symposium On Computer Applications In Medical Care*, 1993, pp. 271-275.
5. Haug PJ, Gardner RM, Tate KE, Evans RS, East TD, Kuperman G, Pryor TA, Huff SM, Warner HR. Decision Support In Medicine: Examples From The HELP System. *Computers And Biomedical Research*, 27, 1994, pp. 396-418.
6. Roberts MS, Zibrak JD, Siders A, Zullo N, and Peterson M: The Development of an On-Line, Partially Automated Discharge Summary and Core Clinical Data-Base in an Existing Hospital Information System. *Symposium On Computer Applications In Medical Care*, 1989. pp. 271-275
7. Trace D, Naeymi-Rad F, Haines D, Robert JJS, Almedia FD, Carmony L, Evans M. Intelligent Medical Record - Entry (IMR-E). *Journal Of Medical Systems*, Vol. 17, Nos. 3/4, 1993, pp. 139-150.